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A Prototype of Low Cost Heads Up Display for Automobiles Navigation System

Siddhant Chouksey
MIT, Pune
Savitribai Phule Pune University
Maharashtra, India
siddhantchouksey@gmail.com

Sumedha Sirsikar
MIT,Pune
Savitribai Phule. Pune University
Maharashtra, India
sumedha.sirsikar@mitpune.edu.in

Abstract*— At the time of World War-II with advent of fighter planes Heads-Up display (HUD) were invented to assist pilot with their targets and navigation. Heads up display is a device which have a transparent display on which information is displayed, it is kept right in line of sight of driver or pilot. With advancement of technology the automobiles are equipped with features and machinery for making driving safe and comfortable example automatic windows, speedometer, milometer and displays for navigation etc. The equipment for driver navigation assistance are usually placed on dashboard of car. To see the information on display each time driver has to shift his focus from the road to the dashboard, which is if not fatal can be dangerous. To overcome the above mentioned problem Heads-Up display can be the solution. In this paper an economical prototype of HUD is presented which displays the symbols turn by turn with the other useful information for navigation on a transparent screen which is placed in line of sight of driver. Compared to existing complex, expensive HUD which are not in the reach of masses due their high cost, the innovative prototype of HUD is presented. The HUD proposed takes the advantage of mobile phones capability for building low cost system. The mobile application with the Arduino Uno, Bluetooth module and 2.8'' TFT are used to create this gadget. This paper also present the results of the experiment performed to check the effectiveness of system.

Keywords*— *Heads Up Display; Augmented reality; Navigation system; Safety;

I. INTRODUCTION

To make more accurate and reliable navigation technology, Global Positioning System (GPS) a space based navigation system was started as a project by United States Department of Defense (DoD) in 1973. With advancement of technologies GPS is adopted by mass population. Mobile phones and applications like Google map has brought a big revolution in navigation technology. Today any one with mobile phone having GPS, by using application like Google Map can navigate the routes with ease, adding to this user can also navigate route for going by a car or by walking. Traffic status on the route, each turn by turn instructions for navigation, estimated time to reach the destination are the few features to be named which are included in Google Map. Now a day's automobiles are also having a navigation system in it, which is placed usually on the dashboard. While driving it is very important that driver concentration should be on the road but the problem is that for navigation the driver has to look in to their mobile phones or onboard displays at dashboard which is not at all safe and can lead to accidents. Generally, a normal human takes 1.2-1.5 seconds for observing the scene which is displaying on phone or dashboard and react, this much of time the concentration of driver is not on the road.

Fig. 1. Heads Up Display (HUD) in fighter planes

This distraction caused by usage of mobile phones or onboard displays leads driver on an average driving over .5 miles on a trip of 10 miles which can be hazardous. To solve this problem and make driving experience more convenient and user friendly Heads Up displays (HUD) can be used. Heads Up display are invented at the time of second World War for providing assistance for target system of the fighter planes as shown in Fig. 1. Heads Up display is the see through/transparent display on which important details are projected or displayed. There are lots of Heads Up displays available in the market in the high end cars of Volkswagen and Mercedes. Company named Continent supplies HUD to the car companies which is assembled in to the car at the time of manufacturing. Other than that portable HUD named Navdy, Gramin etc. are also available in the market. Applications like Hudsway are also available for navigation which can be used as a heads up display by putting your mobile phone beneath windshield are available. HUD for car exists already but they tend to be very expensive and usually found only in luxury vehicles. Some companies are developing more affordable device but they also cost several 100 $. In this paper a prototype of economically feasible HUD is presented which can be used for navigation. The heads up display proposed is made by taking advantage of capability of mobile phones, it is smarter way for making heads up display. For mobile the mobile application is made which takes the destination and current location as an input and sends the request to the Google sever by using Google Application Program Interface (API) in mobile application the received information is processed in to string and sent to the hardware that is made by combination of Arduino Uno, HC05 Bluetooth Module and 2.8''colour TFT via Bluetooth. After the string received by the hardware it is processed and necessary information is displayed on TFT screen. For creating transparent display (augmented reality), the signs displayed on the TFT screen are mirrored so that when display is kept beneath windshield by reflection the image is formed on windshield. This paper also discusses the experiment conducted for checking the effectiveness of HUD.

In this paper in section I introduction of scenario of HUD for automobile is given, section II discusses the literature survey, section III describes the proposed system and its implementation, section IV shows the results and experiment which analyzes the HUD effectiveness and at last section V conclusion and future scope is given.

II. Related Work

There has been various researches and surveys on HUD. In these researches the effectiveness, distraction, impact on driving and scope of improvement of HUD is explored. In the paper presented by Joseph L. Gabbard [1] the analysis of HUD is done by imposing virtual image in front of the driver eyes and then reaction is recorded. According to this paper the augmented reality implemented by Heads Up Display is not at its best, the need of driver and visual perception is not yet fully understood by companies or inventor. Gabbard also mentions the importance and advantage of augmented reality related to driver's tasks perform during driving. M. Kivanc Hedili [2] in his paper mentioned the shortcoming of heads-up display which require very large space in front of car and to solve this shortcoming he proposes direct projection heads up display on a windshield which is embedded see through screen which will be compact and elegant and hence takes very low space. Tangmanne [4] explored the effectiveness of signs which are to be displayed by augmented reality and sign boards on road. Tangmanne has presented an experiment in which the subjects are assigned for a car simulation test using an eye tracking device. The data was recorded in terms of eye movement and response time from two types of graphics for same sign in order to measure the driver's distraction. The results show that though the shape of the graphic has no effect, the location of the arrows does. Marcus Tonnis [6] in his paper introduces the features of longitudinal and lateral driver assistance. For longitudinal assistance presentation scheme indicates the braking system by a virtual bar on the road and for lateral assistance adds the visualization of drive-path between the car and the bar. Tonnis in his paper presented he the analysis of assistance given by the display on two parts longitudinal and lateral both are compared by performing experiments. Patrica R.J.A Alves [3] report is on the system that gives the warning to avoid forward collision and proposes two metaphors for symbol in each case, the metaphor comparisons are shown in this paper using a simulation.

There are also lots of patents and papers are available but all of them have some shortcomings some are very expensive some are complex some are having low or no visibility at day light. The proposed HUD is made by considering all the shortcoming.

III. Proposed System and Its Implementation

The proposed system can be divided in to two parts hardware and software. The hardware part includes a mobile phone with GPS and Internet. Since mobile prices has been declined on an average 9 out of 10 mobile users have internet and GPS in their mobile phones.

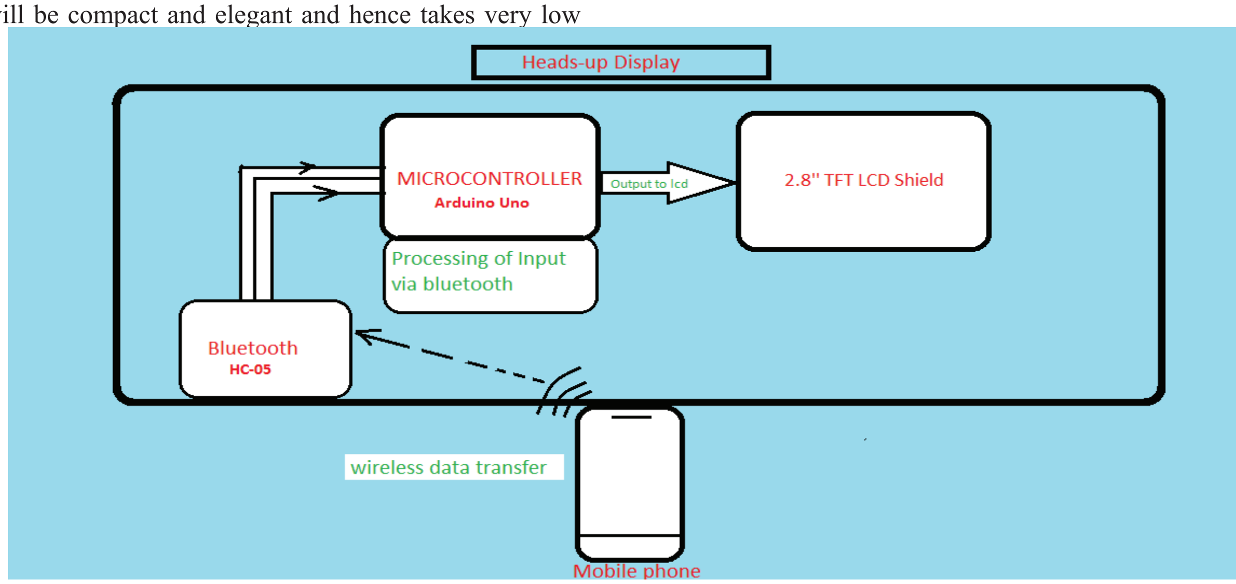


Fig. 2. Block Diagram of HUD

The block diagram of whole system is shown in Fig.2. HC-05 Bluetooth is low price serial port protocol module it has enhanced data rate of 3 Mbps. Arduino shields are the boards that can be plugged on top of the Arduino PCB which makes them easy to mount. 2.8'' TFT LCD shield comes with SD card port it 240x320 pixels with individual pixel control, have 18-bit 262,000 colorful different shades. Software used for creating HUD are for Android app Eclipse Juno is used and for doing programing of Arduino, Arduino Software (IDE) the open-source is used.

In hardware part the TFT and Bluetooth (HC05) are connected to the Arduino uno as shown in Fig. 3 and Fig. 4 respectively since Bluetooth and TFT both requires 3.3v, 5v and ground pin so they are

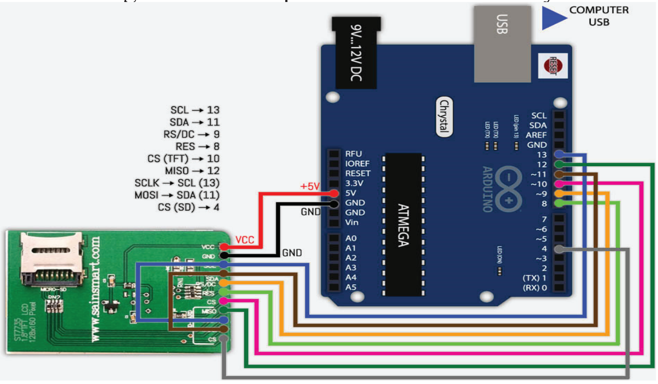


Fig. 3. Arduino Uno connection with TFT

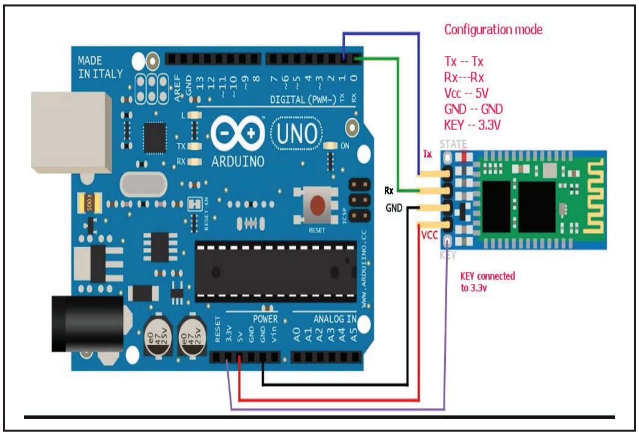


Fig. 4. Arduino Uno connection with HC-05 Bluetooth module

connected in parallel. Mobile phone contains an Android application which requires GPS, internet and Bluetooth. After connecting to the HUD via HC-05 Bluetooth it takes destination as an input from the user. The Android application is made by using JSON, Google Map API, Google places API, Google Geolocation API and Bluetooth API as shown in Fig 5. After starting the application on mobile phones the app will connect automatically to the HUD as and when it gets connected the destination window pops up in which user has to type the address and to make it user friendly the app has auto fill feature which is done by using Google places API which gives the list of addresses which are similar to the typed words so after choosing the appropriate address from the list destination address is set. The current location longitude and latitude is taken as current address and destination address which is filled by user both are sent to the Google server by using the Google maps API this API on return gives the pool of information in JSON format.

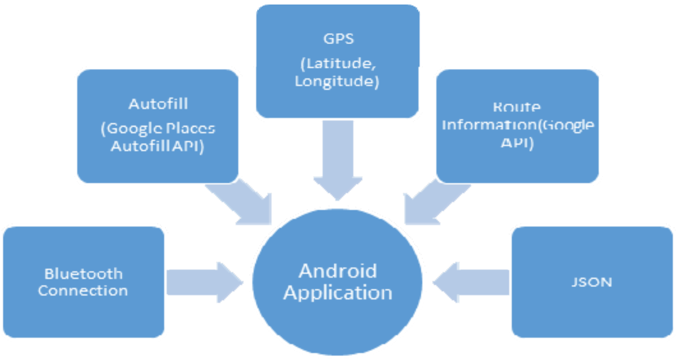


Fig. 5. Blocks diagram of Android Application for HUD

The information has the data which contains the all steps to be taken to reach the destination and also have instructions, and maneuver to be performed while taking the steps for reaching destination. Since we need to perform first step given in data retrieved in JSON format, so the string variable is declared which stores the maneuver to be performed, distance after which this maneuver to be performed, the estimated time and distance to take the step, total distance and time for reaching the destination all are concatenated in one string separated by the '|' operator. This string is sent to the HUD (Hardware) by Bluetooth. Fig. 6 shows the sample the string. Periodically with change in current longitude and latitude the current address is changed, so with new current address request is again sent to Google server by using API, this time the data received will have the current location changed and accordingly it gives steps so again the string is loaded with standard format and again sent to the HUD (hardware) by Bluetooth. The string received by the Bluetooth module connected with Arduino, microcontroller is programmed for continuously receiving mode of Bluetooth data, as and when it receives the string it breaks the strings in to maneuver, total distance, time etc. parts as explained above and then according to the maneuver it prints the symbol of arrows showing the directions. Google maps has total 18 types of maneuvers so according to the receives maneuver the direction arrows are displayed on TFT. The displayed image is the mirror image of actual direction so when HUD is placed below windshield the reflection of mirror image of mirrored image will give the real image. The Table 1 shows the types of maneuver with their symbols that are possible that is reflected windshield.

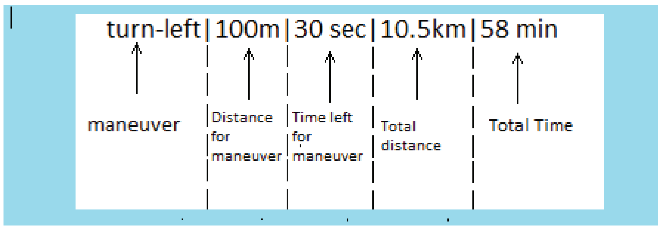
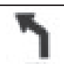


Fig. 6. String sent by Bluetooth

TABLE I. Maneuver and symbols

Maneuver	Symbol	Abbreviations
turn-sharp-left		TSL
uturn-right		UT
turn-slight-right		TSR
merge		M
roundabout-left		RL
roundabout-right		RR
uturn-left		UL
turn-slight-left		TSL
turn-left		TL
ramp-right		RR
turn-right		TR
fork-right		FR
straight		S
fork-left		FL
turn-sharp-right		TSR
ramp-left		RL

IV. Experiment and Results

The HUD with some directions displayed on transparent screen similar to windshield are shown in the Fig. 7. To check the impact and accuracy of Heads-up display 10 subjects have taken for experiment. Firstly, the signs for each maneuvers are taught to drivers with their abbreviations as shown in Table I, so that drivers know name of each type of arrows. the condition was that as and when driver will speak first word of abbreviation of the arrow the response time is recorded and considered to calculate average if the rest of abbreviation is correct. The stop watch is used to measure response time. The subjects are not aware where they have to go but subjects have to follow the instruction provided by the HUD while driving. To maintain the traffic condition same, on the same time for next 10 days ten different subjects 'A', 'B', 'C', 'D', 'E' 'F', 'G', 'H', 'I' and 'J' has driven the car on the same route following the instruction on HUD. Again same 10 subjects have driven the car on different route of same distance and with same maneuvers but this time driver has to follow the navigation shown in their dashboards. The response time is observed and recorded by the another person in a car with stop watch. The average response time of all maneuvers performed for understanding the direction from dash boards and by HUD is calculated for each subject those are recorded by the observer in the car with the driver. The graph shown in Figure 6 summarize the results. The Table 2 and 3 shows the response time for each maneuver performed by subjects with HUD and without HUD. The route followed by subjects with their maneuvers are as given below:

Route 1 with HUD:
From: Nirman Bhawan, New Delhi
Longitude and Latitude:(28.610411,77.21741399999996)
To: Udyog Bhawan, Metro Station, New Delhi
Longitude and Latitude: (28.611014,77.21224419999999)
Maneuvers:

i. Turn-left
ii. Roundabout-left
iii. Straight

Route 2 without HUD:
From: Udyog Bhawan, Metro Station, New Delhi
Longitude and Latitude: (28.611014, 77.21224419999)
To: Rashtrapati Bhawan, New Delhi
Longitude and Latitude: (28.611014, 77.21224419999999)
Maneuvers:

i. Turn-left
ii. Roundabout-left
iii. Straight

As clearly shown by the graph the response time of the subjects reduce by more than half when heads-up display is used for navigation compare to the other case the response time of driver to understand the navigation instruction is 1 second or more. Which shows that heads-up display greatly reduces the response time of driver. According to the feedback of the subjects the HUD makes ride more comfortable, safe and easier than before now driver don't have to adjust their focus and hence make driving safer. The HUD presented works well it makes driving safer. The cost of whole project is below 1000 INR. 1000/- which makes it economical and yet it performs all navigation function similar other HUD available in the market because of this with further improvements this prototype can be developed as a gadget which is affordable by middle class also.

TABLE II. Response time and average response time of subjects with HUD

Manoeuvres	A		B		C		D		E		F		G		H		I		J	
	RT	C/I	RT	C/I	RT	C/I	RT	C/I	RT	C/I	RT	C/I	RT	C/I	RT	C/I	RT	C/I	RT	C/I
Turn-left	0.5	C	0.4	C	0.3	C	0.6	C	0.4	C	0.3	C	0.3	C	0.4	C	0.5	I	0.3	C
Roundabout-left	0.4	C	0.3	C	0.2	C	0.3	C	0.3	C	0.4	C	0.3	C	0.4	C	0.3	C	0.4	C
Straight	0.3	C	0.3	C	0.3	C	0.3	C	0.4	C	0.3	C	0.3	C	0.4	C	0.3	C	0.4	C
Average (Seconds)	0.4		0.33		0.26		0.4		0.36		0.33		0.3		0.4		0.3		0.36	

Where RT=Response time; C/I= Correct/Incorrect

TABLE III. Response time and average response time of subjects with navigation on dashboard

Manoeuvres	A		B		C		D		E		F		G		H		I		J	
	RT	C/I	RT	C/I	RT	C/I	RT	C/I	RT	C/I	RT	C/I	RT	C/I	RT	C/I	RT	C/I	RT	C/I
Turn-left	1	C	1.4	C	1.3	C	1.3	C	1.2	C	1.4	C	1.6	C	1.5	C	0.9	I	1.1	C
Roundabout-left	0.8	C	1.2	C	0.9	C	0.9	C	1.1	C	0.8	C	1	C	1.5	C	1.2	C	1.3	C
Straight	1.2	C	0.9	C	1	C	1.1	C	1	C	1.4	C	1.3	C	1.4	C	1.1	C	1.2	C
Average (Seconds)	1		1.16		1.01		1.1		1.1		1.2		1.3		1.46		1.12		1.2	

Where RT=Response time; C/I= Correct/Incorrect

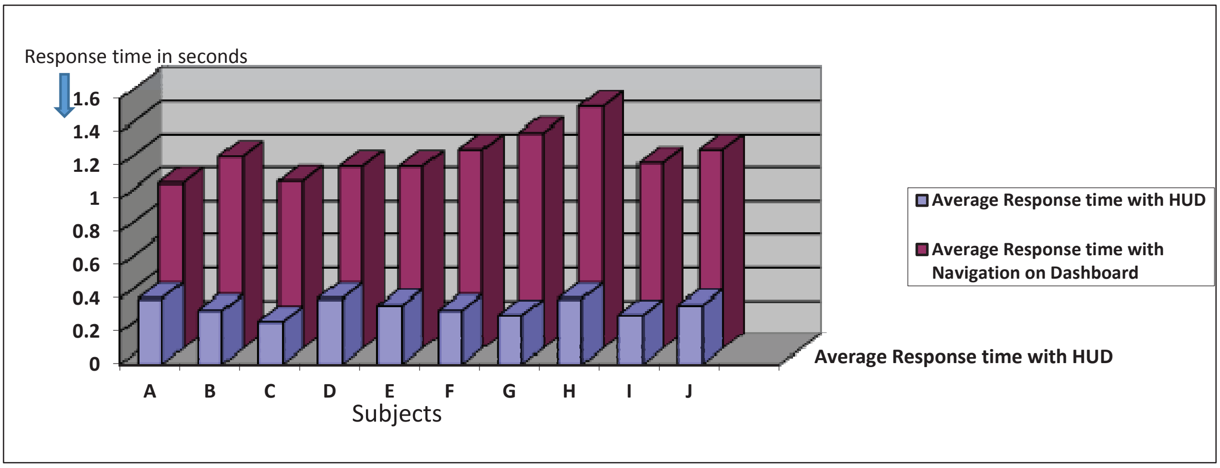


Figure 6. Response time of subjects

V. Conclusion and Future Scope

Presented HUD in this paper is made by using the capability of mobile phones which makes the whole system very economical compared to other HUD's in the market. The presented HUD is capable of displaying instructions and turn by turn directions which makes driving safer and comfortable.

Heads Up display for automobiles can be used for providing many type of features and assistance to the driver. In future it can be integrated with the voice recognition, voice control, gesture control so that while driving without touching the touch screen or any other input device simply by gesture of voice command the HUD can perform the functions. Adding to the navigation feature HUD can also be used for picking up a call, texting, playing music, volume control of music, operating head lamps of automobile, operating windows and roof of a car and many more. HUD with integrating sensors can be used to form Ad-hoc network which can be used for creating traffic management system. HUD is a platform; it is the future. With new innovation in augmented reality in upcoming future HUD are also able to sense the objects and they can also be integrated with the automatic driving system to give user a best experience possible.

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